

Precipitation Nowcasting in the Canary Islands with Deep Learning Tools at EWCloud

David Quintero Plaza, AEMET, Spain. EWCloud Meeting, November 10th, 2021

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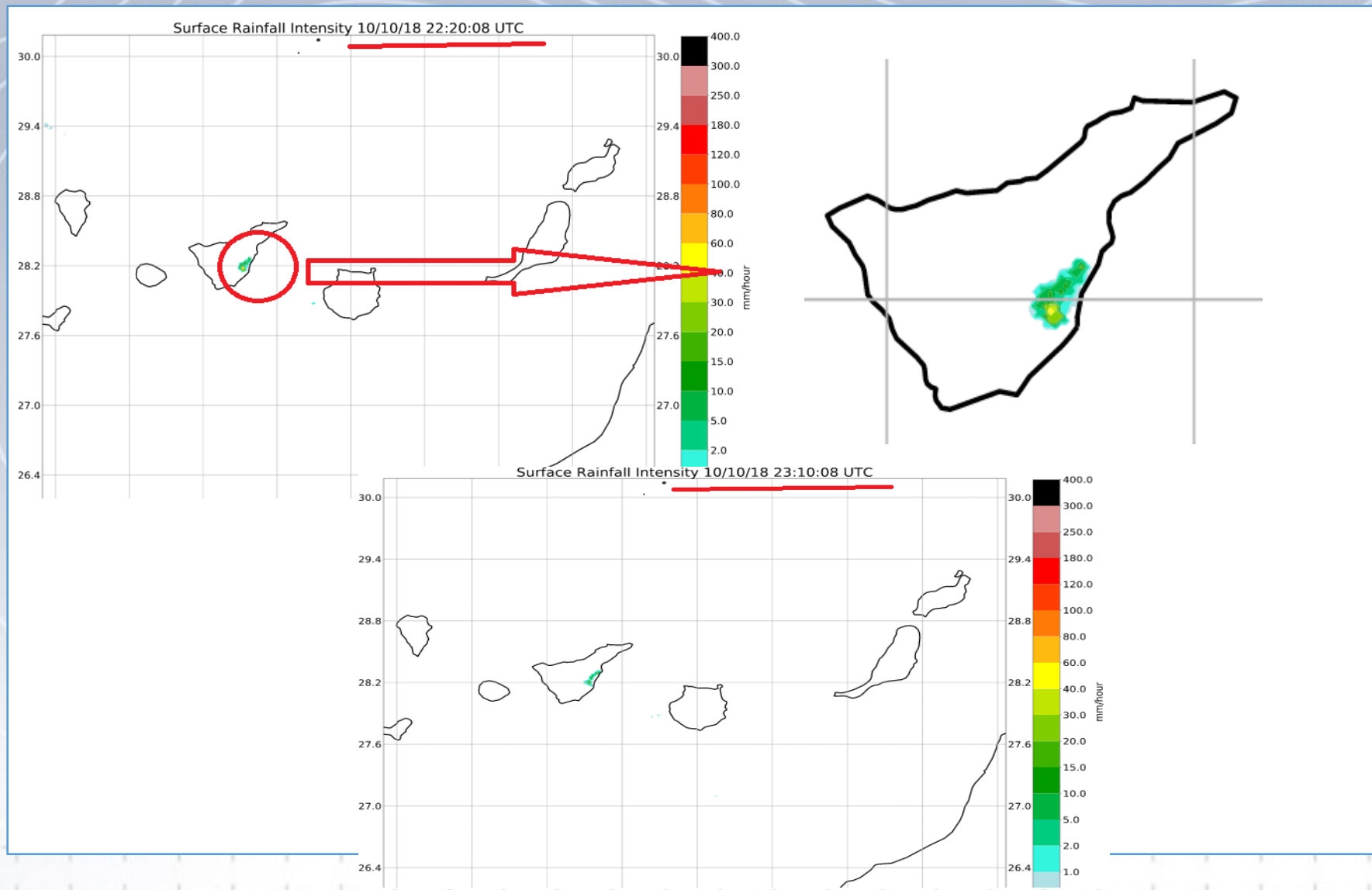
1. The Canary Islands: a challenge for modelization.
2. Deep learning for precipitation nowcasting.
 - 2.1. EWCloud setup.
 - 2.2. First trainings.
3. A glimpse to the future.

- The islands have a complex, mountainous and fastly changing terrain, with the so called local “micro-climates”.



- Even High Resolution Models (Harmonie & gSREPS at 2.5 Km) still show limitations for the islands (not to mention models with less resolution).
- Affected by middle latitudes and tropical phenomena.

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- Regarding the nowcasting: 3 possibilities,
 - Fast Integration Models.
 - Optical Flow.
 - **Neural Networks and other Machine Learning approaches.**
- Some evidence that Machine Learning/Deep Learning is on equal terms (and sometimes beating) more *classical* options...

MetNet: A Neural Weather Model for Precipitation Forecasting. <https://arxiv.org/abs/2003.12140>

Convcast: An embedded convolutional LSTM based architecture for precipitation nowcasting using satellite data. PLoS ONE 15(3): e0230114. <https://doi.org/10.1371/journal.pone.0230114>

All convolutional neural networks for radar-based precipitation nowcasting. Procedia Computer Science Volume 150, 2019, Pages 186-192. <https://doi.org/10.1016/j.procs.2019.02.036>

- Working with the radar.



- The variable chosen was **SRI (Surface Rainfall Intensity)**, an estimated value of the instantaneous precipitation using data from all the vertical, as offered by the IRIS SIGMET-VAISALA radar, **each 10 minutes, in mm/hour**.
- Beware of the limitations: radar located at 1778 meters above sea level & many holes in the historical dataset!

- User environment at the EWCloud...



- *conda* installation of different libraries, especially NumPy, **Tensorflow for GPU (tf-gpu=2.3, cudnn=7.6, cudatoolkit=10.1)** and wradlib (for radar data reading).

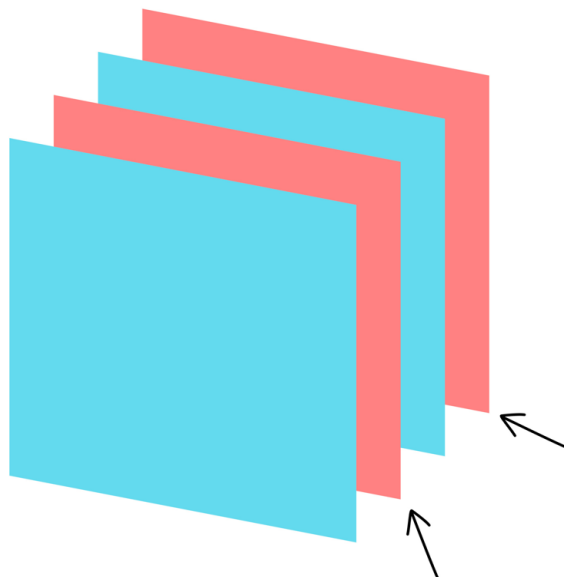
- Algorithm chosen: **RainNet, by Georgy Ayzel**: a combination of ResNet and U-Net neural networks.

Ayzel, G., Scheffer, T., and Heistermann, M.: RainNet v1.0: a convolutional neural network for radar-based precipitation nowcasting, Geosci. Model Dev., 13, 2631–2644, <https://doi.org/10.5194/gmd-13-2631-2020>, 2020.

<https://github.com/hydrogo/rainnet>



- RainNet takes the last 4 images and predicts the next one (5th). Then, it takes the “new” last 4 images (including the predicted before) and predicts the 6th, and so on...
- Original work: German radar with pcp accumulations each 5 minutes. Our radar: accumulations per hour and each 10 minutes => transform and interpolate. **Important step.**



- German dataset: 900x900 matrices converted to 928x928 (U-Net needs rows and cols multiple of 2^{n+1} , n number of max pooling layers, 4 in the original design). Our case: 480x480, already multiple of 32.

- A glimpse into the code... more than 31 millions of parameters to train in our case:

```
inputs = Input(input_shape)

conv1f = Conv2D(64, 3, padding='same', kernel_initializer='he_normal')(inputs)
conv1s = Activation("relu")(conv1f)
conv1s = Conv2D(64, 3, padding='same', kernel_initializer='he_normal')(conv1s)
conv1s = Activation("relu")(conv1s)
pool1 = MaxPooling2D(pool_size=(2, 2))(conv1s)

conv2f = Conv2D(128, 3, padding='same', kernel_initializer='he_normal')(pool1)
conv2s = Activation("relu")(conv2f)
conv2s = Conv2D(128, 3, padding='same', kernel_initializer='he_normal')(conv2s)
conv2s = Activation("relu")(conv2s)
pool2 = MaxPooling2D(pool_size=(2, 2))(conv2s)

conv3f = Conv2D(256, 3, padding='same', kernel_initializer='he_normal')(pool2)
conv3s = Activation("relu")(conv3f)
conv3s = Conv2D(256, 3, padding='same', kernel_initializer='he_normal')(conv3s)
conv3s = Activation("relu")(conv3s)
pool3 = MaxPooling2D(pool_size=(2, 2))(conv3s)
```

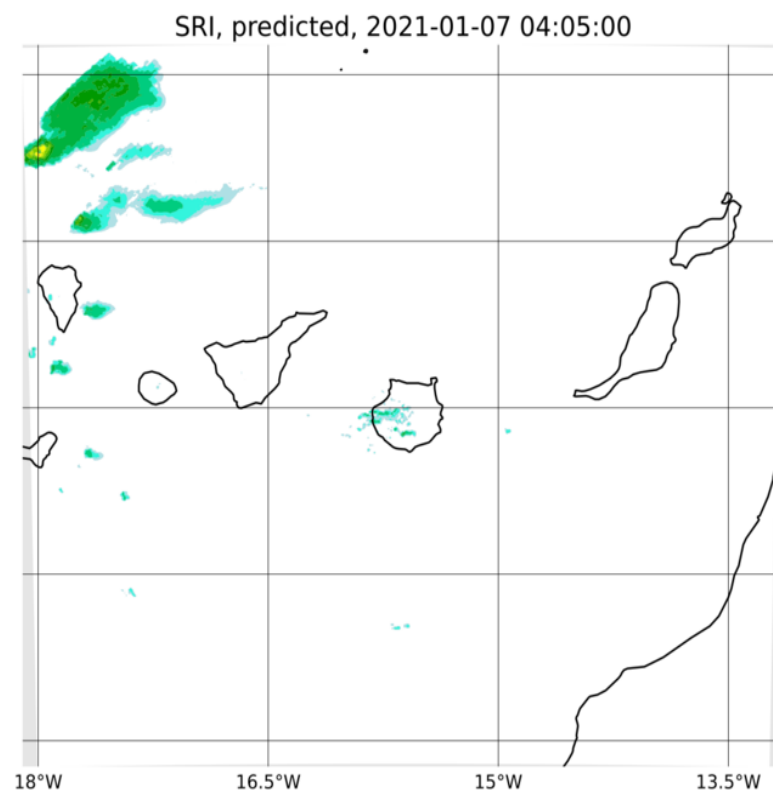
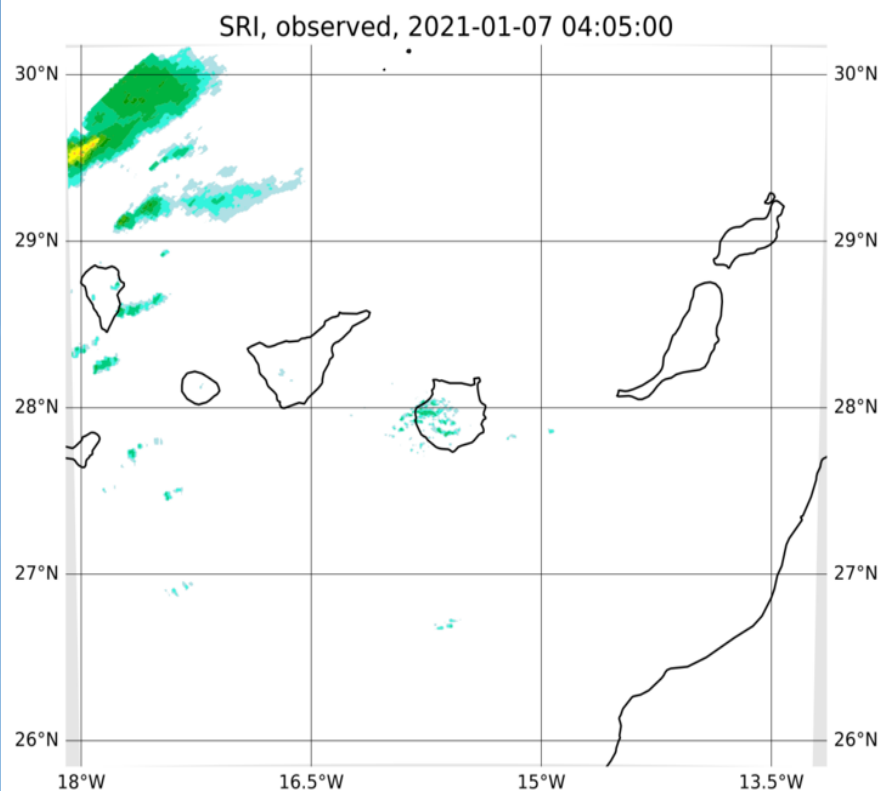
- It needs GPUs!

- Our dataset has holes.
- Training has to be done with a temporal set of files without holes (temporal ordering is important).
- **Workflow:**
 - 1) Download historical data (SRI) from the radar until a hole appears.
 - 2) Do the necessary transformations on the dataset downloaded in 1.
 - 3) Training (early stopping, model checkpoint).
 - 4) Go back to 1 and repeat.

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- **A first validation...** (with the training set, not valid!! It is just to show).

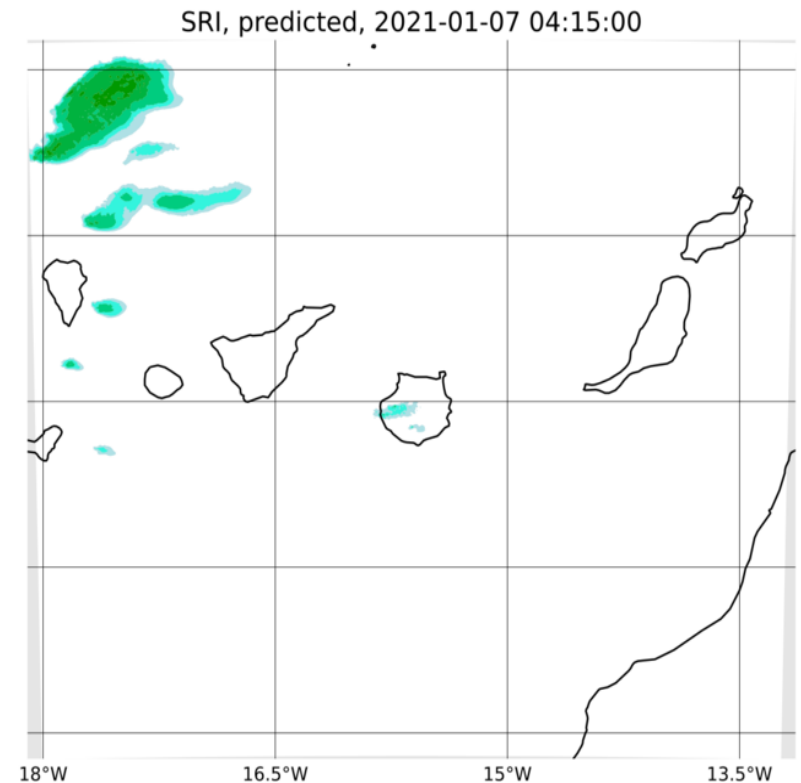
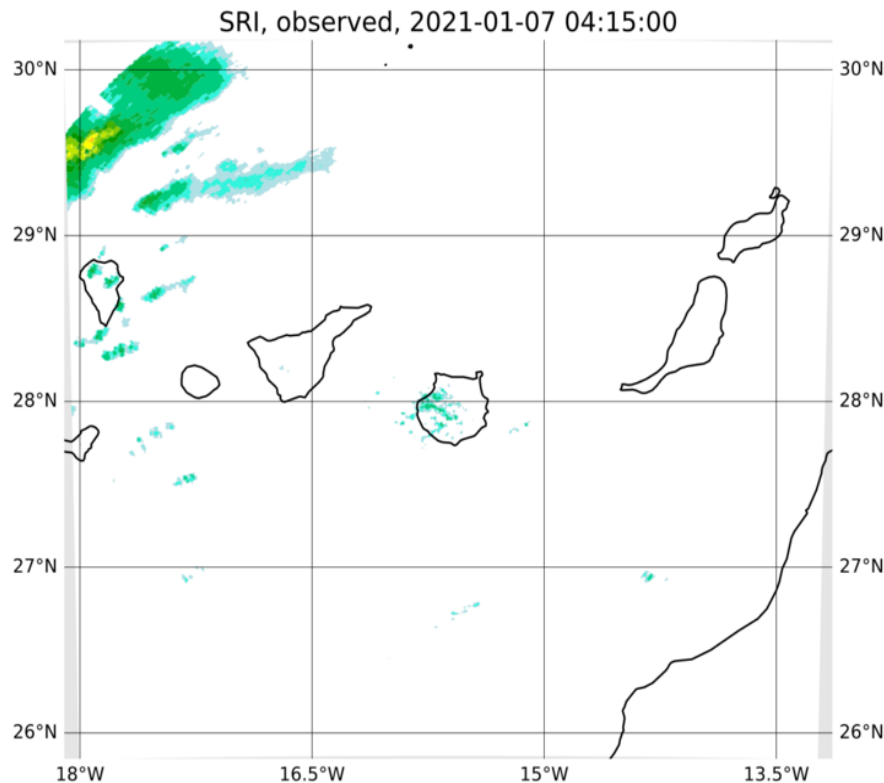
T+10 minutes:



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- **A first validation...** (with the training set, not valid!! It is just to show).

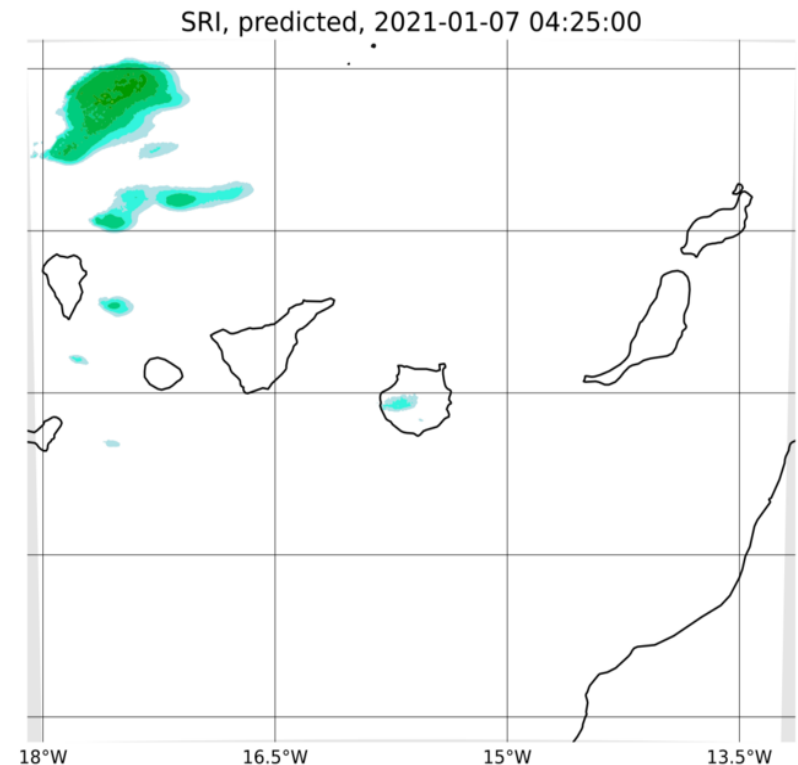
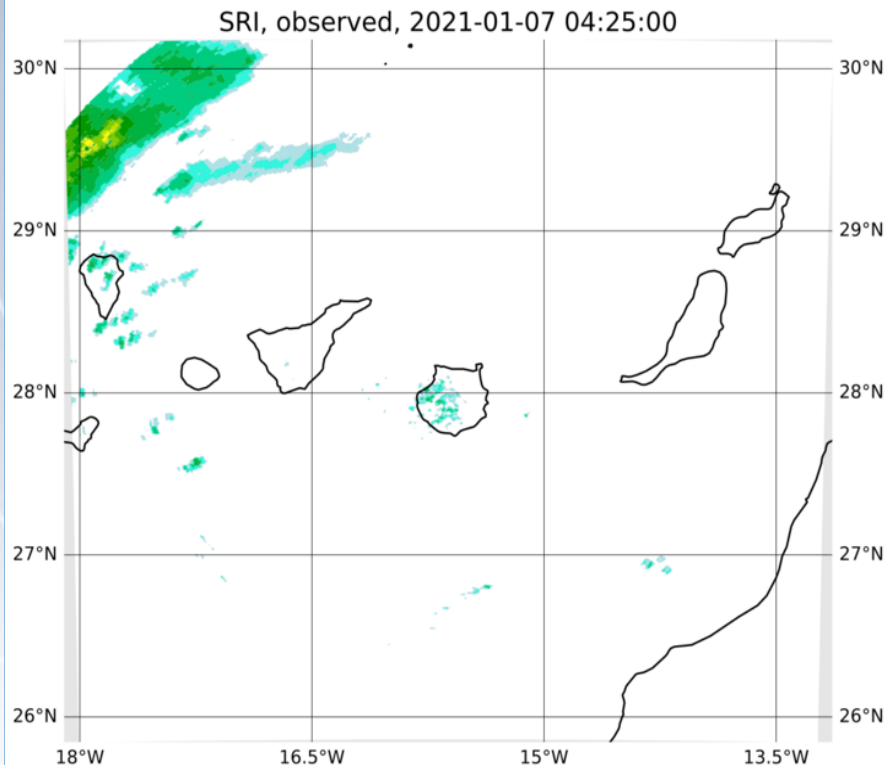
T+20 minutes:



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- **A first validation...** (with the training set, not valid!! It is just to show).

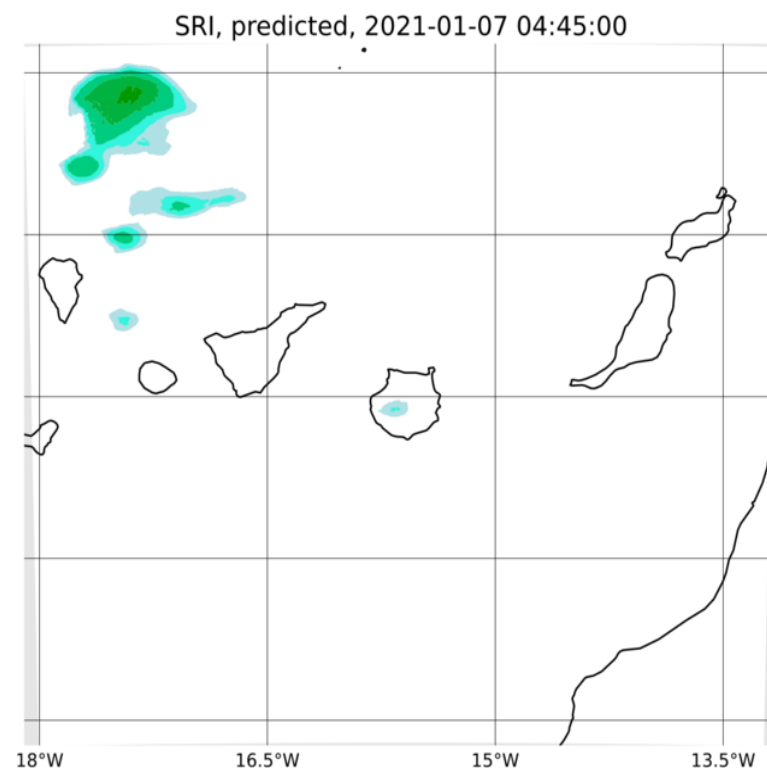
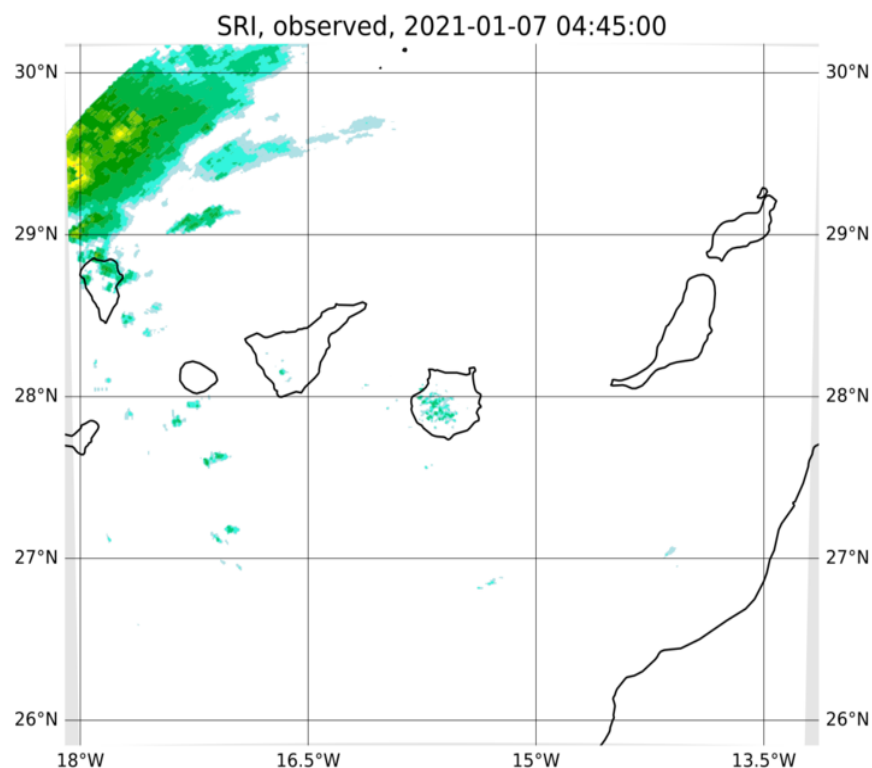
T+30 minutes:



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- **A first validation...** (with the training set, not valid!! It is just to show).

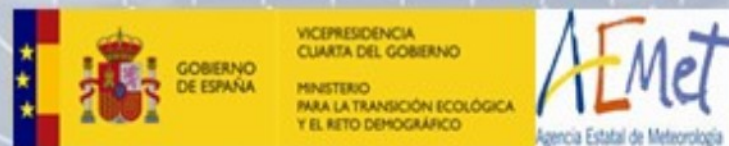
T+50 minutes:



- A glimpse to the future:

- Fix the drastic underestimation of the prediction when time increases. (One NN for each timestep? Other NN architectures? Increase training dataset?...)
- From test to the operative chain.
- Make tests with ConvLSTM neurons as suggested by part of the literature.
- Train in other areas besides the Canary Islands? Wetter regions?
- From radar to satellite?
- More exotic NN architectures (e.g. GANs)?

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References:

- P. 3: Left image: By Iven Gummelt - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=4040284>
Central image: By Jens Steckert - Own work, CC BY-SA 3.0, <https://commons.wikimedia.org/w/index.php?curid=765158>
Right image: By Daniel Gaínza (Tenerife) - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=4555690>
- P. 7: Icon EWCloud from <https://www.europeanweather.cloud/>
Icon RainNet from <https://github.com/hydrogo/rainnet>
- P. 9: From <https://github.com/hydrogo/rainnet/blob/master/rainnet.py>